



2000 International ADAMS Users Conference

Linking ADAMS/Car and ADVISOR for Advanced Vehicle Evaluation

Keith Wipke

Senior Engineer, Vehicle Systems Analysis Team
National Renewable Energy Laboratory

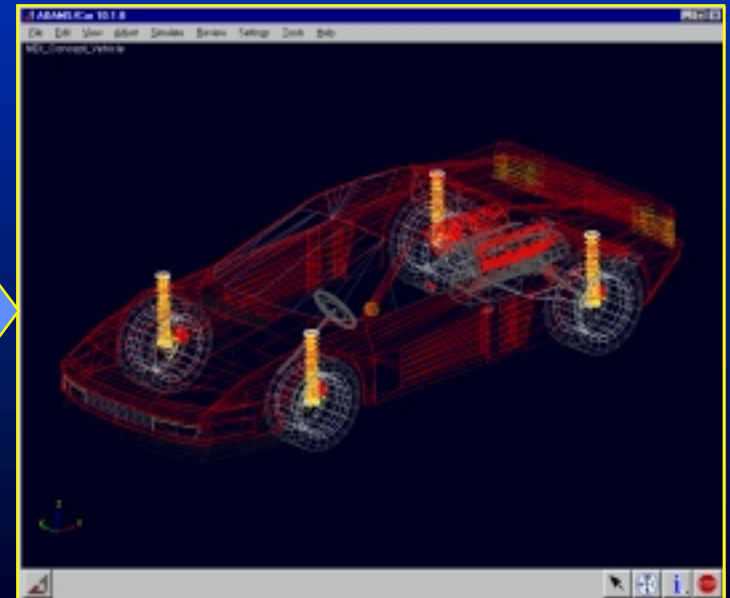
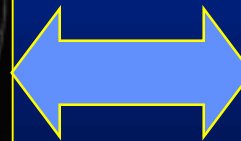


CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Presentation Outline

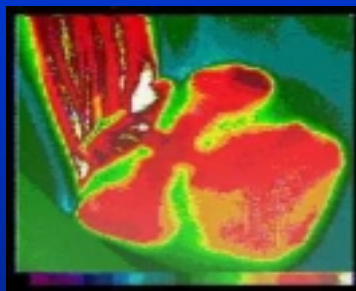
- Background and demonstration of ADVISOR 2.2
- Example of previous linkage with packaging
- Objectives of linking ADVISOR and ADAMS/Car
- Two approaches to making linkage
 - ADAMS/ADVISOR Co-simulation
 - Export to ADAMS/Car



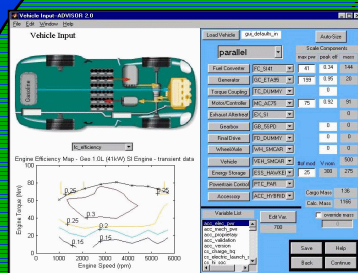
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Light-Duty Hybrid Electric Vehicle Program



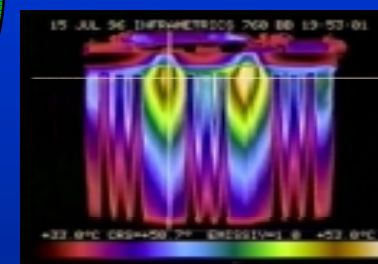
Vehicle Climate Control



Vehicle Systems Analysis



Digital Functional Vehicle



Battery Thermal Management

Big 3 Partnership
(55 mpg, mid-size vehicle)



DaimlerChrysler



Ford



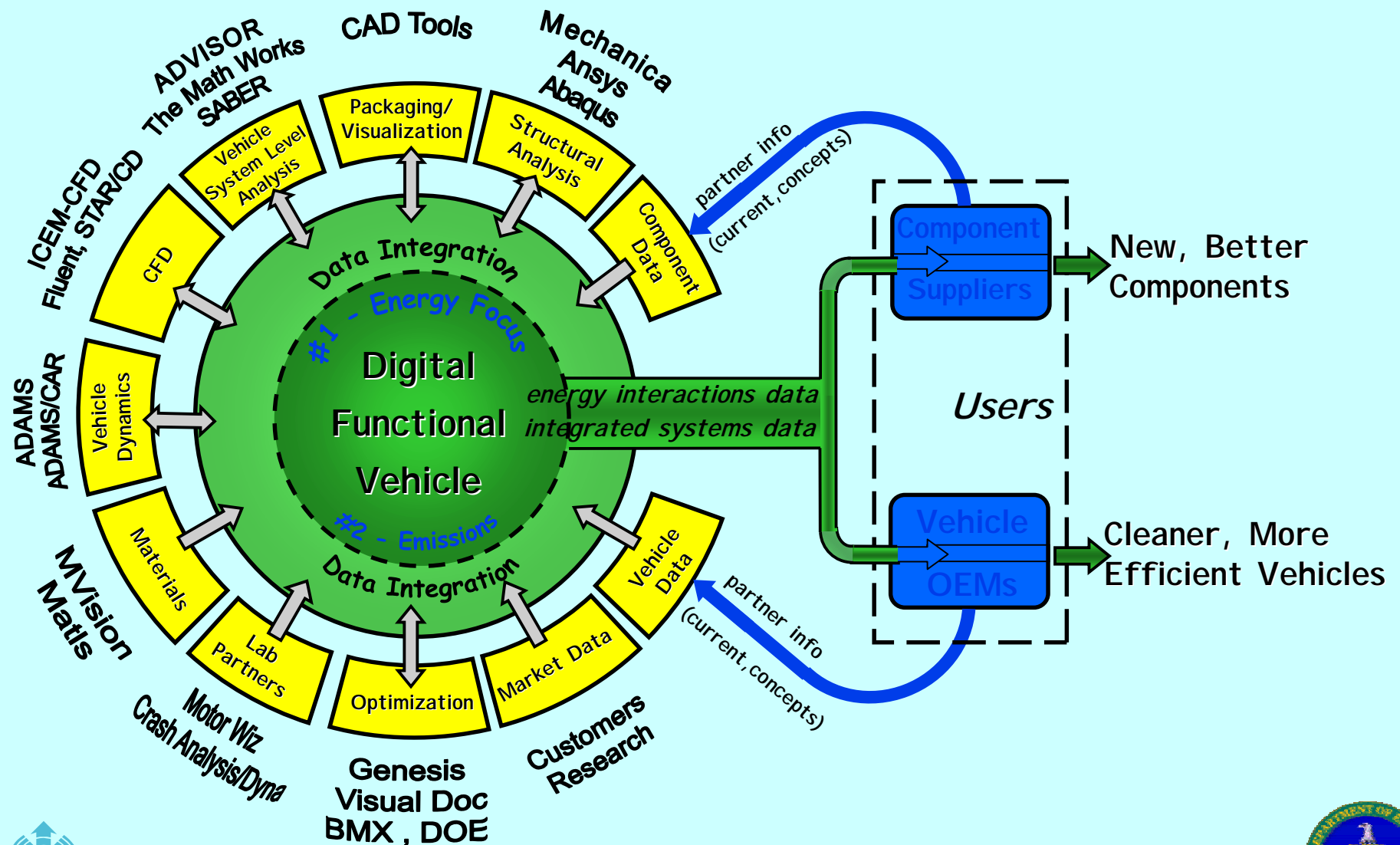
GM



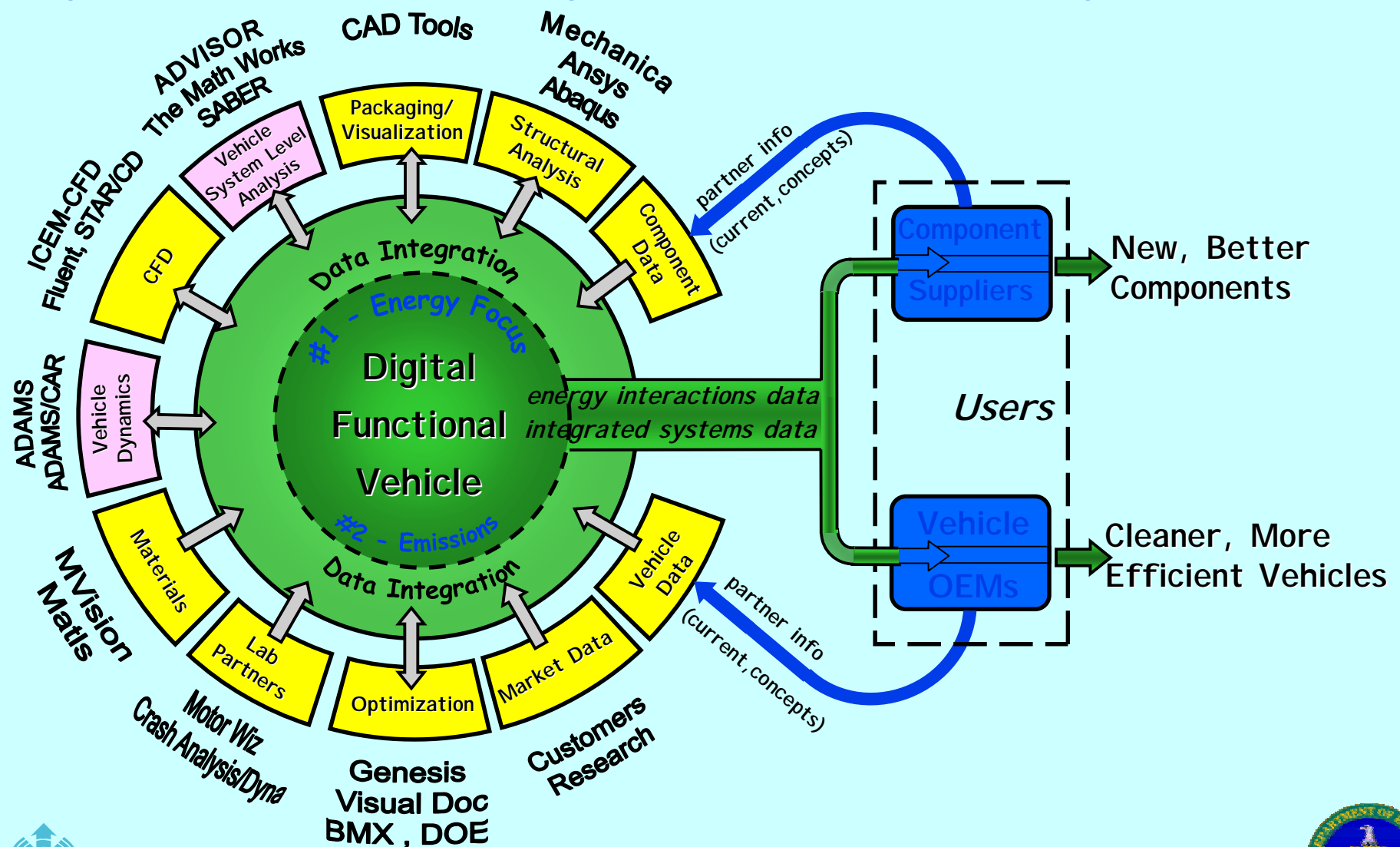
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Digital Functional Vehicle Data Integration Wheel

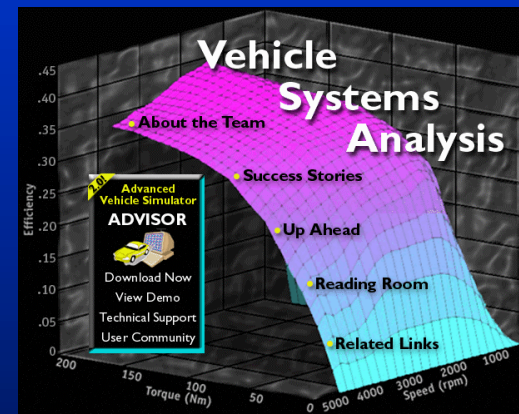


Digital Functional Vehicle Wheel: Linking Systems Level Analysis with Vehicle Dynamics



Background on ADVISOR

- ADVISOR = ADvanced Vehicle Simulator
 - simulates conventional, electric, or hybrid vehicles (series, parallel, or fuel cell)
- ADVISOR was created in 1994 to support DOE Hybrid Program at NREL
- Released on vehicle systems analysis web site in September, 1998
- Programmed in MATLAB/Simulink
- Downloaded by over 1700 people around world
- Users help provide component data and validation

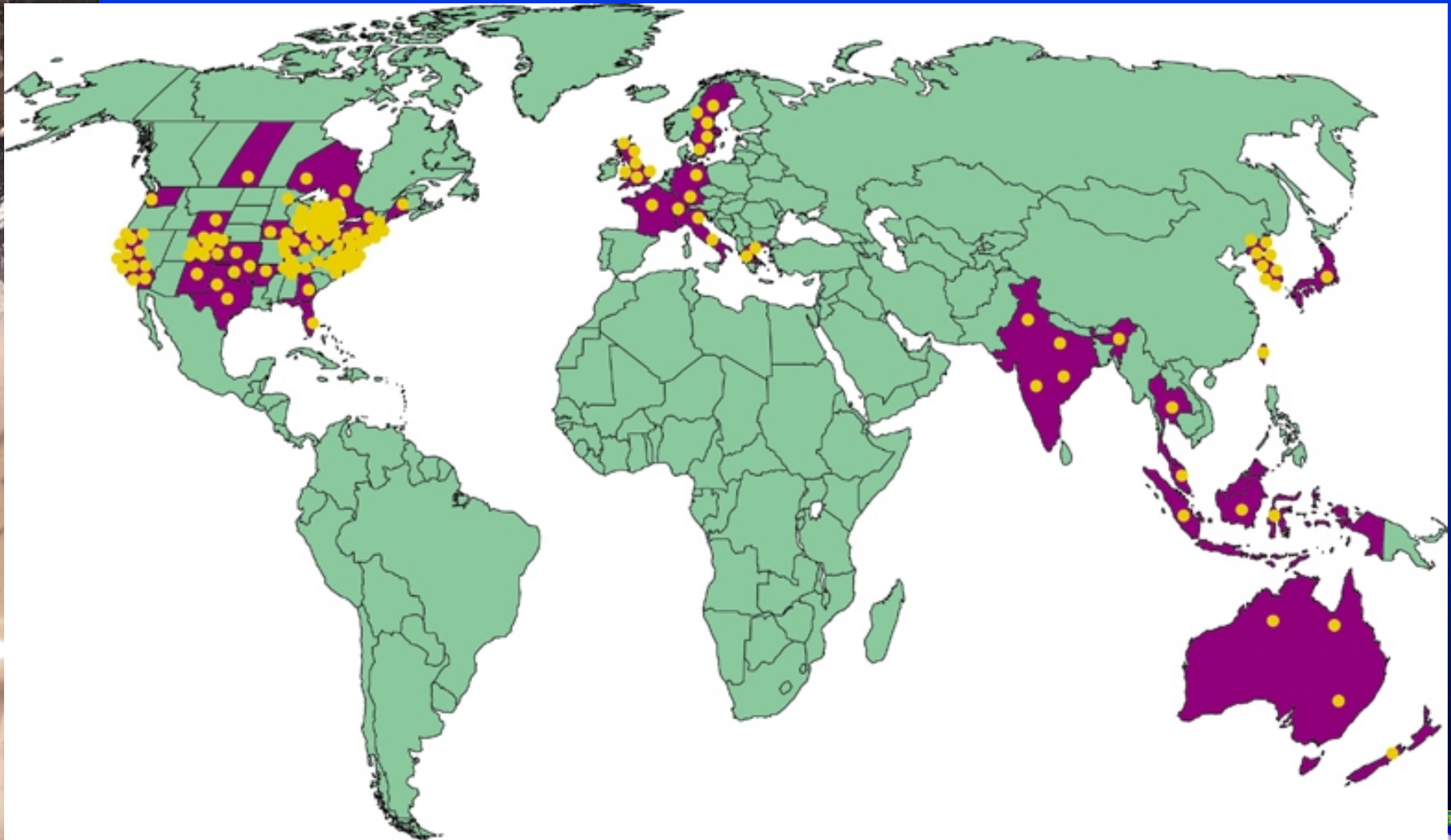


CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



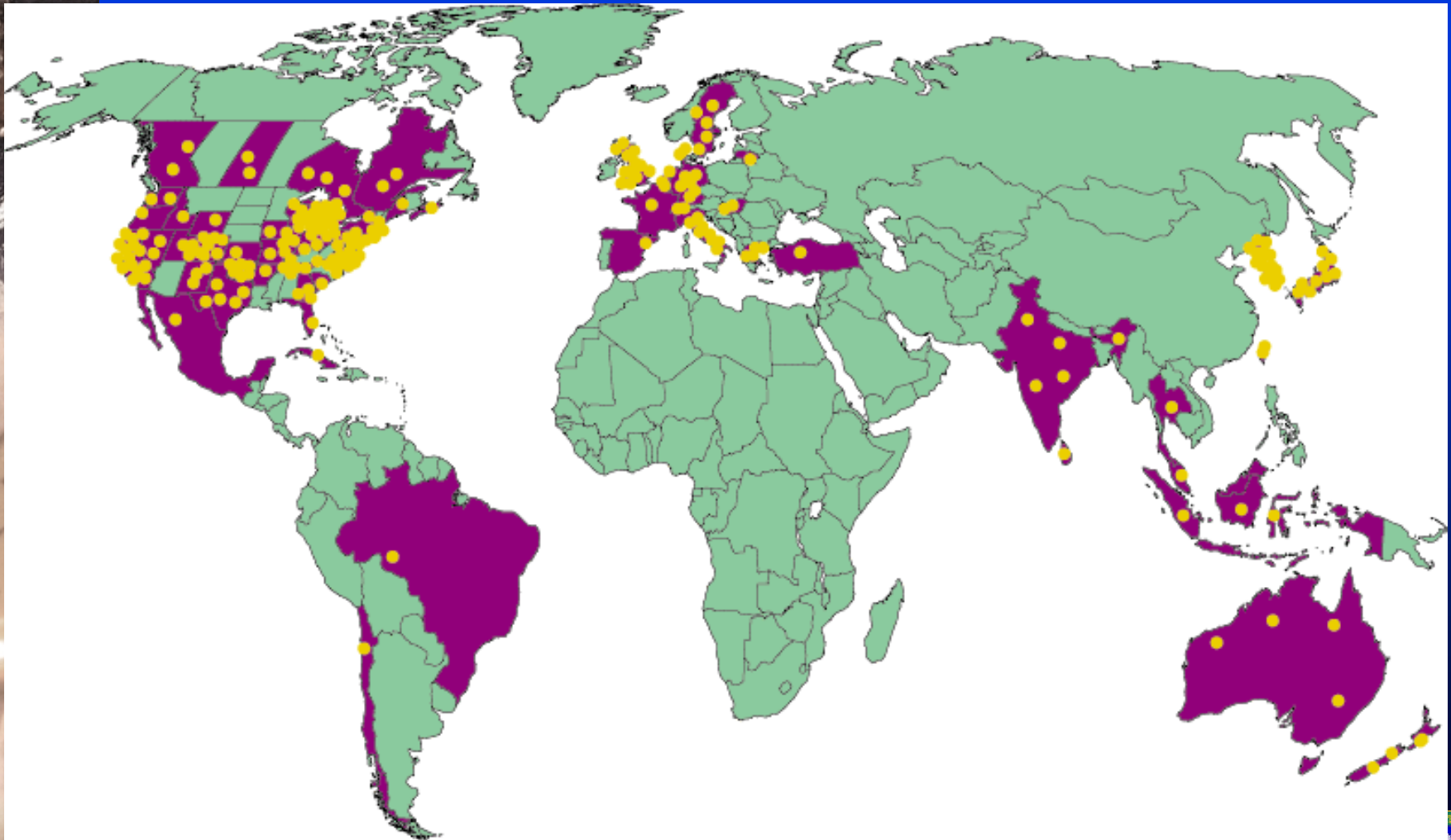
ADVISOR Being Used Globally

November 1998: ~130 users



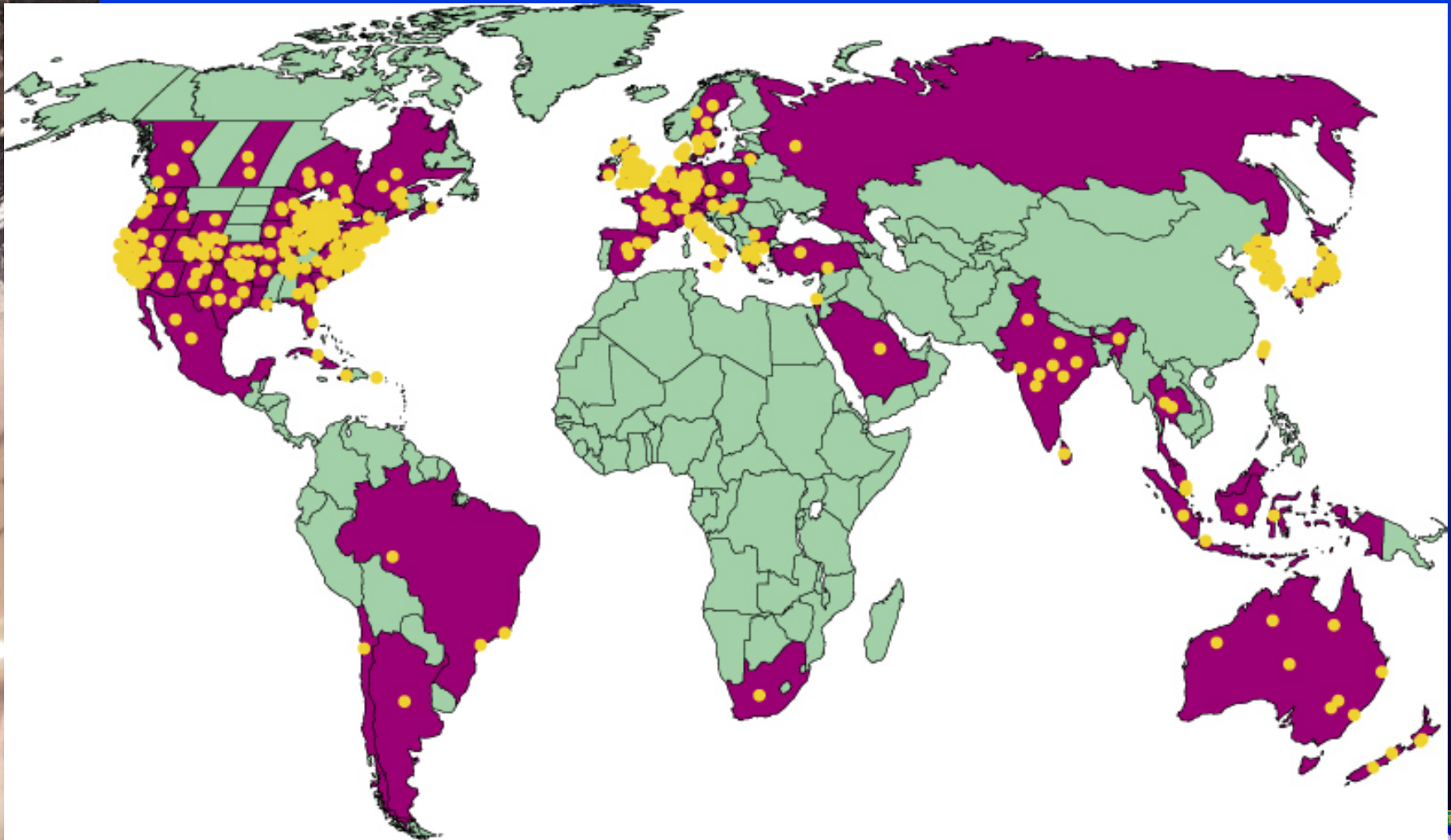
ADVISOR Being Used Globally

January 1999: ~330 users



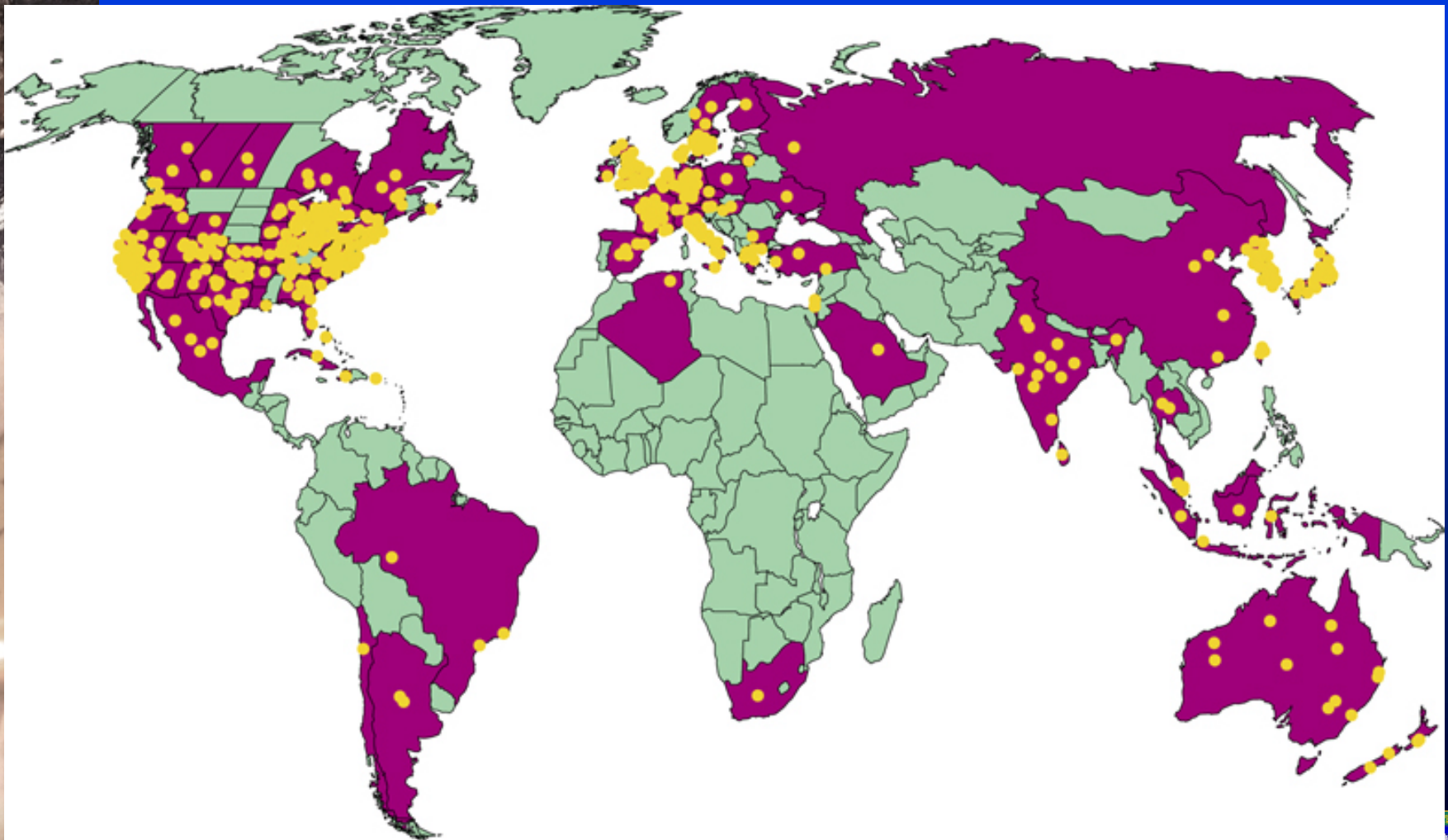
ADVISOR Being Used Globally

March 1999: ~500 users



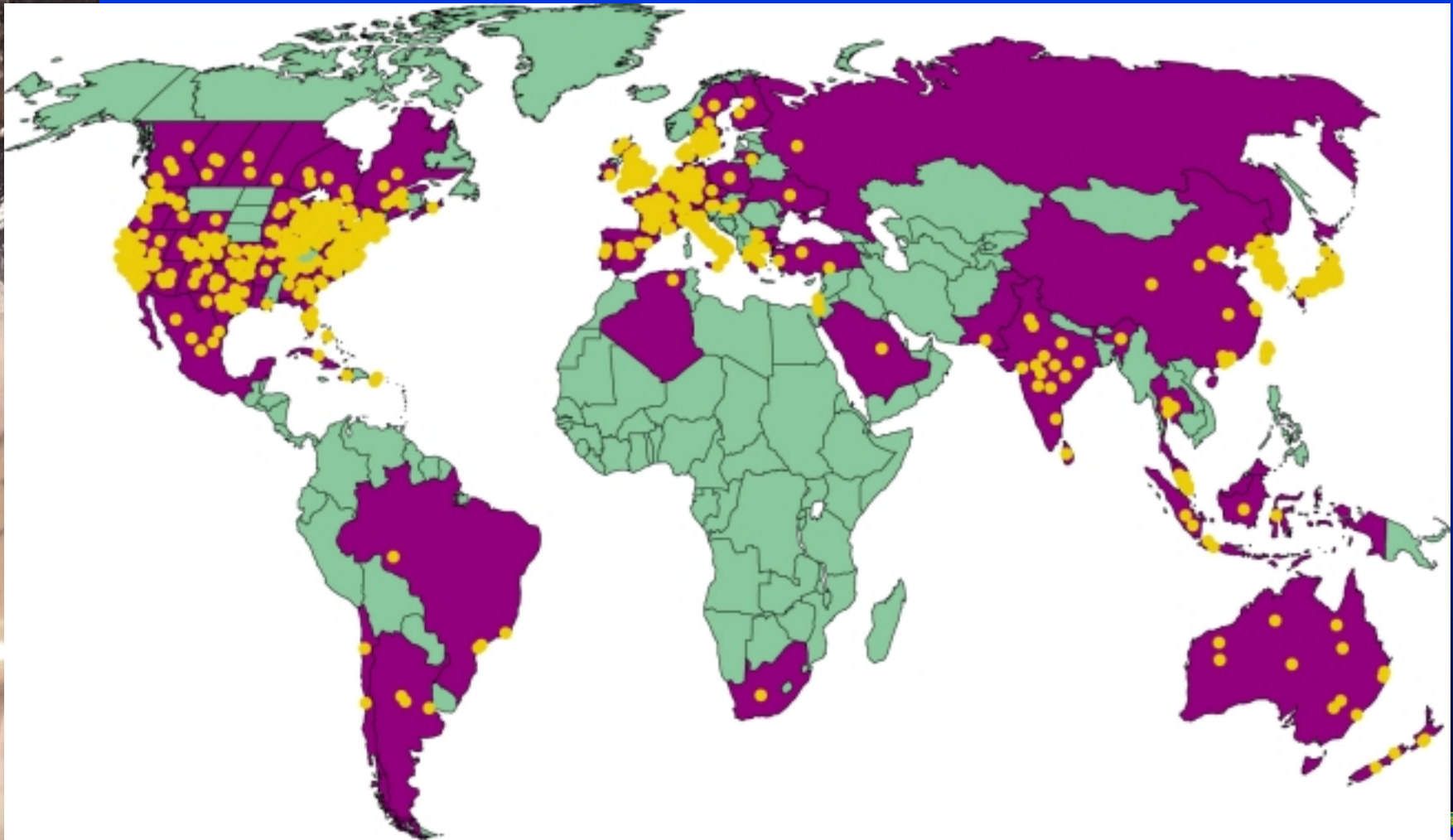
ADVISOR Being Used Globally

August 1999: ~800 users

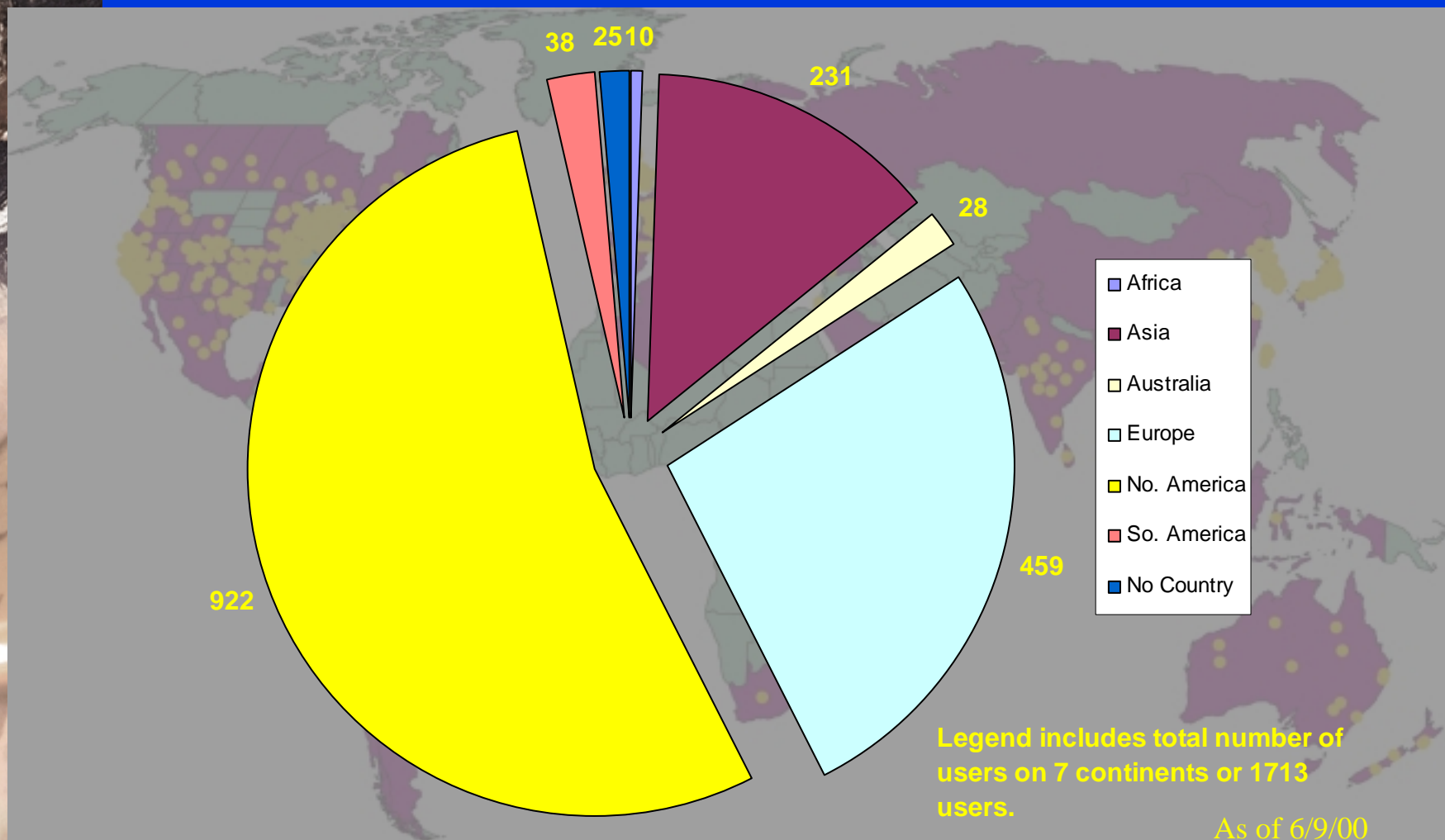


ADVISOR Being Used Globally

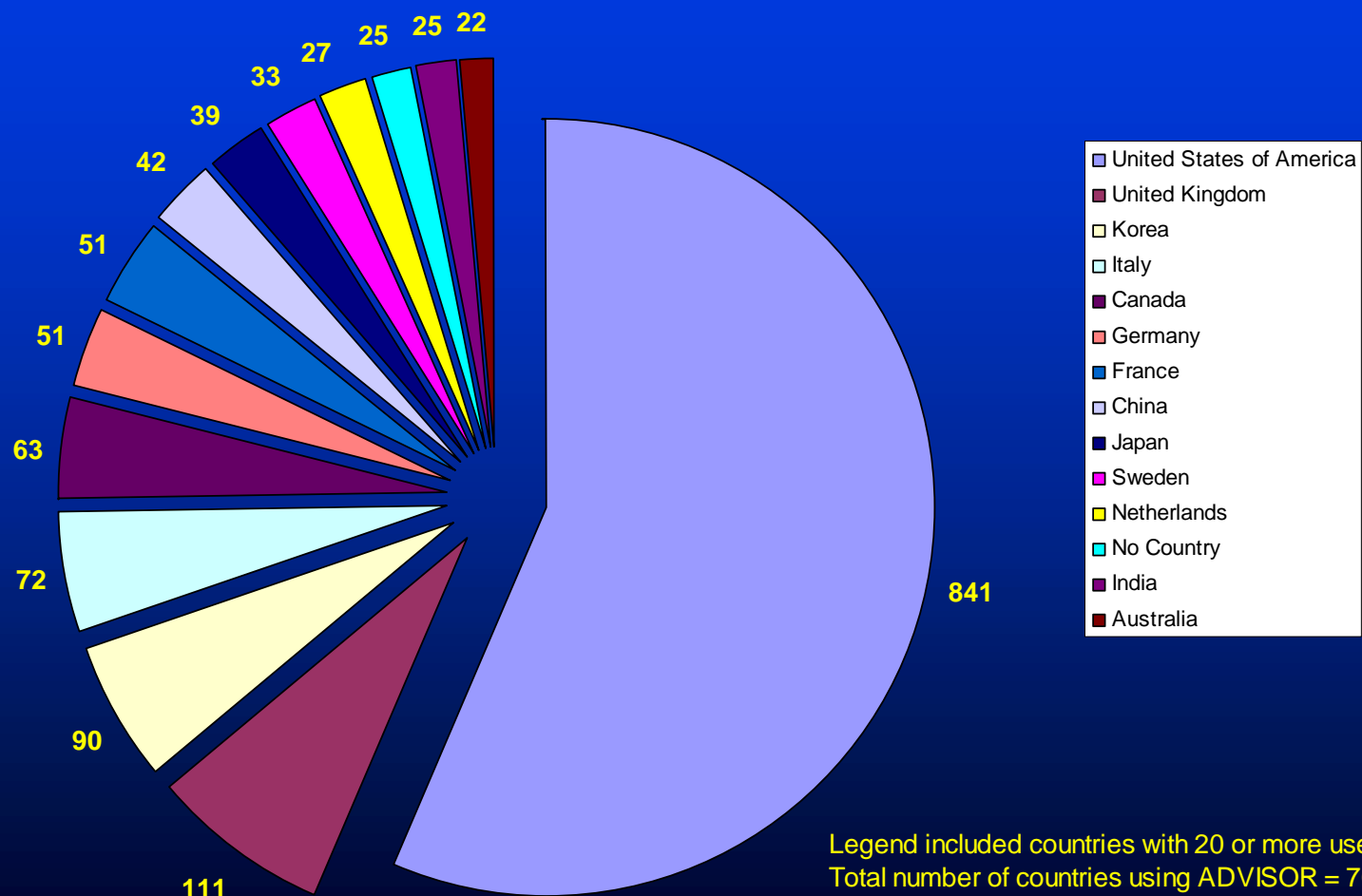
June 2000: ~1700 users



ADVISOR Downloads by Continent



ADVISOR Downloads by Country

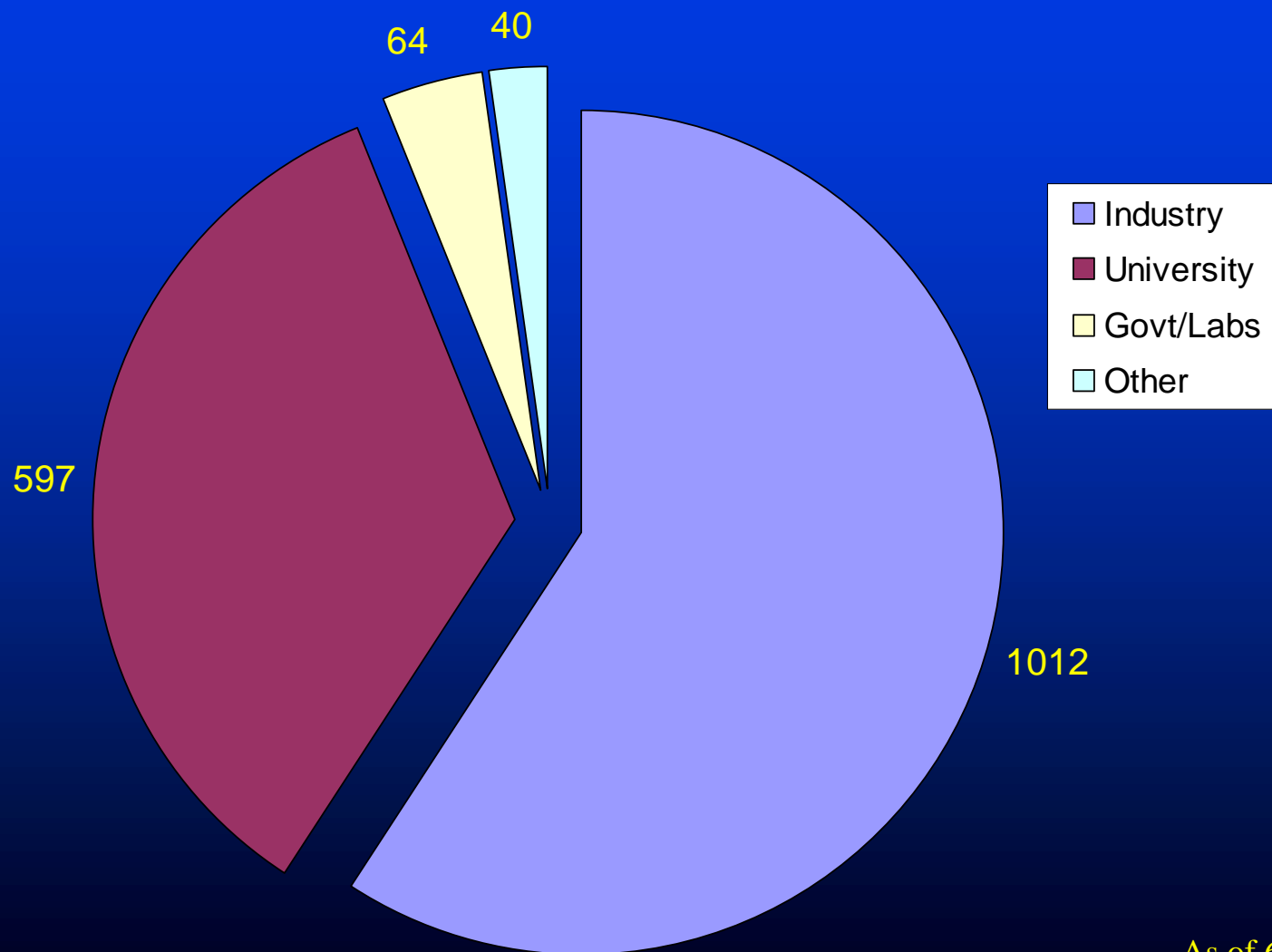


CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS

As of 6/7/00



ADVISOR Downloads by Type of Organization



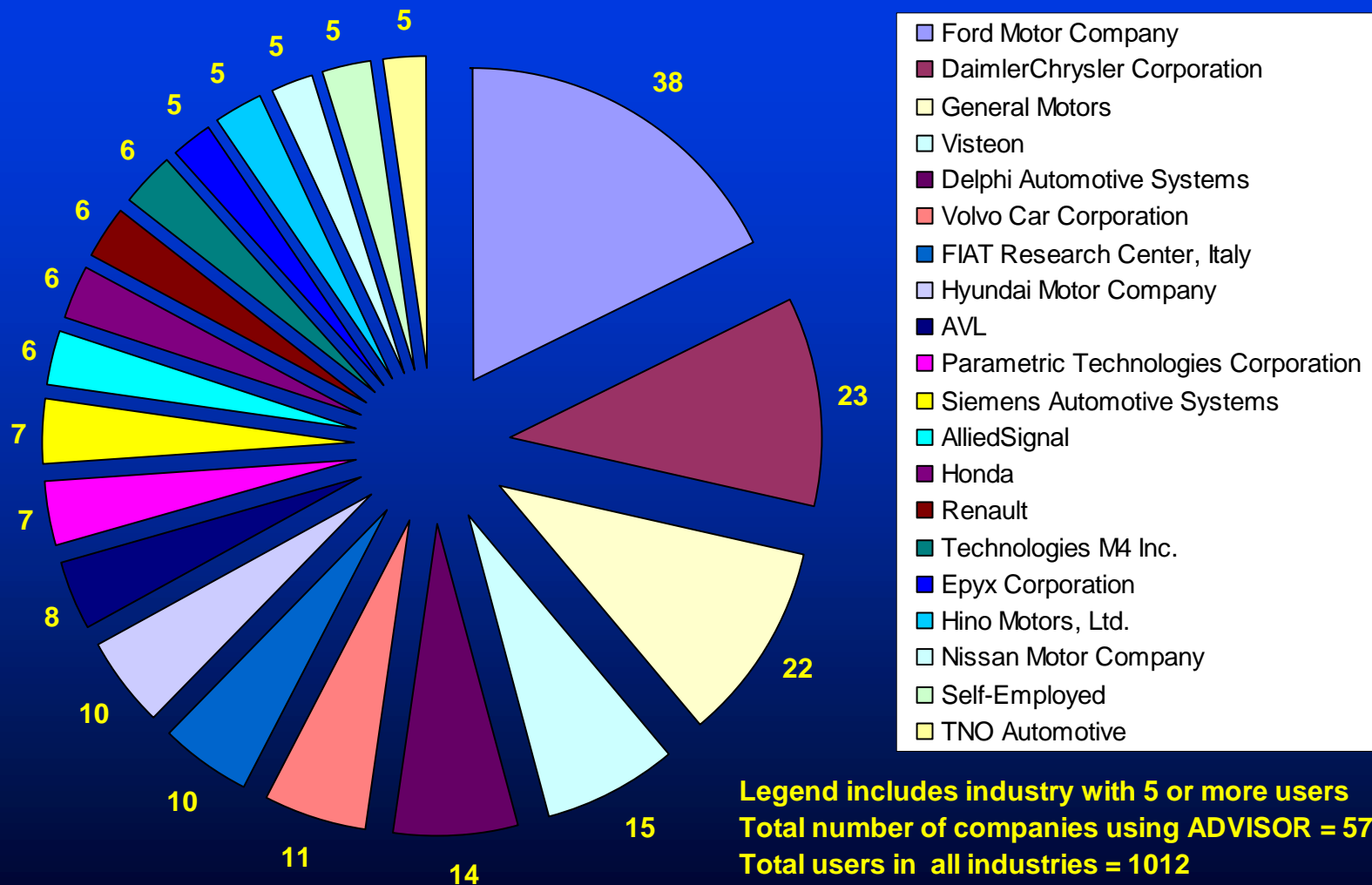
As of 6/7/00



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



ADVISOR Downloads by Industry



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS

As of 6/7/00



ADVISOR Users Conference: August 2000



The screenshot shows a web browser window titled "Systems Analysis ADVISOR - Microsoft Internet Explorer provided by NREL". The address bar shows "http://www.ctts.nrel.gov/analysis/conference.html". The page features a navigation bar with links: "ADVISOR", "About the Team", "Success Stories", "Up Ahead", "Reading Room", "Related Links", and "Vehicle Systems Analysis". Below the navigation bar are buttons for "Download Now", "View Demo", "Technical Support", and "User Community". The main heading is "ADVISOR Users Conference". Below the heading is a graphic of a car on a road leading to a mountain. The page lists the following information:

- date** - August 24-25, 2000
- location** - Costa Mesa, CA, [click here for a map](#)
- general info**
 - get more information about the conference
- call for papers**
 - get more information about possible paper or presentation topics
- schedule**
 - timeline for abstract submittal, notification, and conference
- travel**
 - hotel, airport
- sponsorship**
 - we're looking for sponsors, check here for more information
- program**
 - conference program ****Updated****



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS

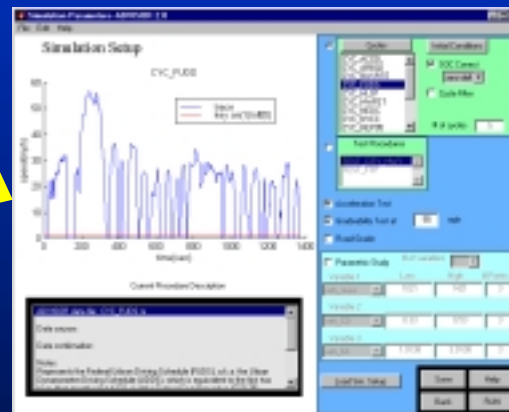


Three Main ADVISOR Screens (Roadmap)

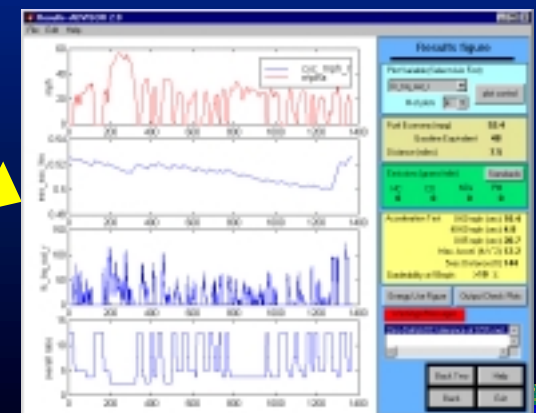
Vehicle Input



Simulation Setup



Results



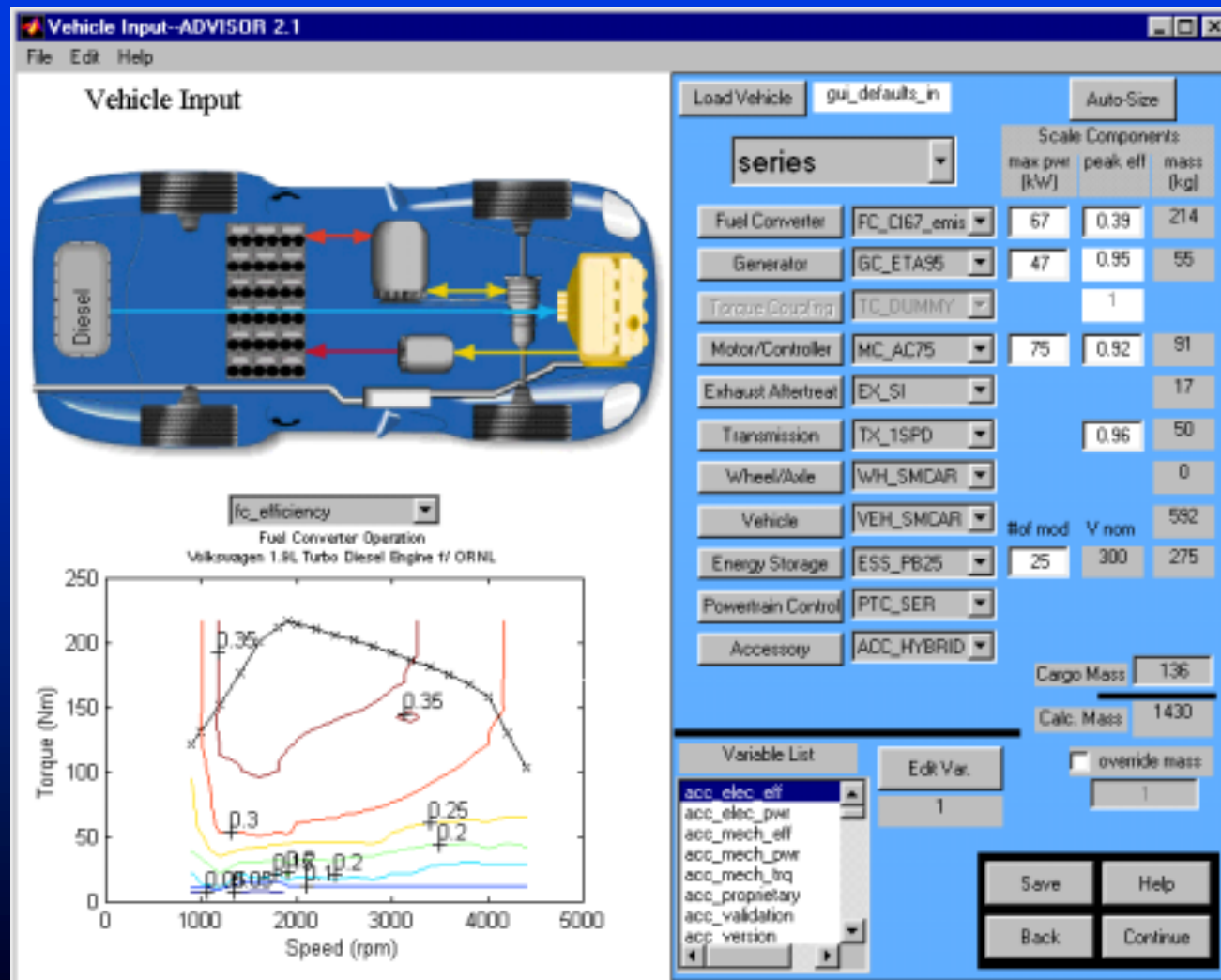
ADVISOR Demonstration



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



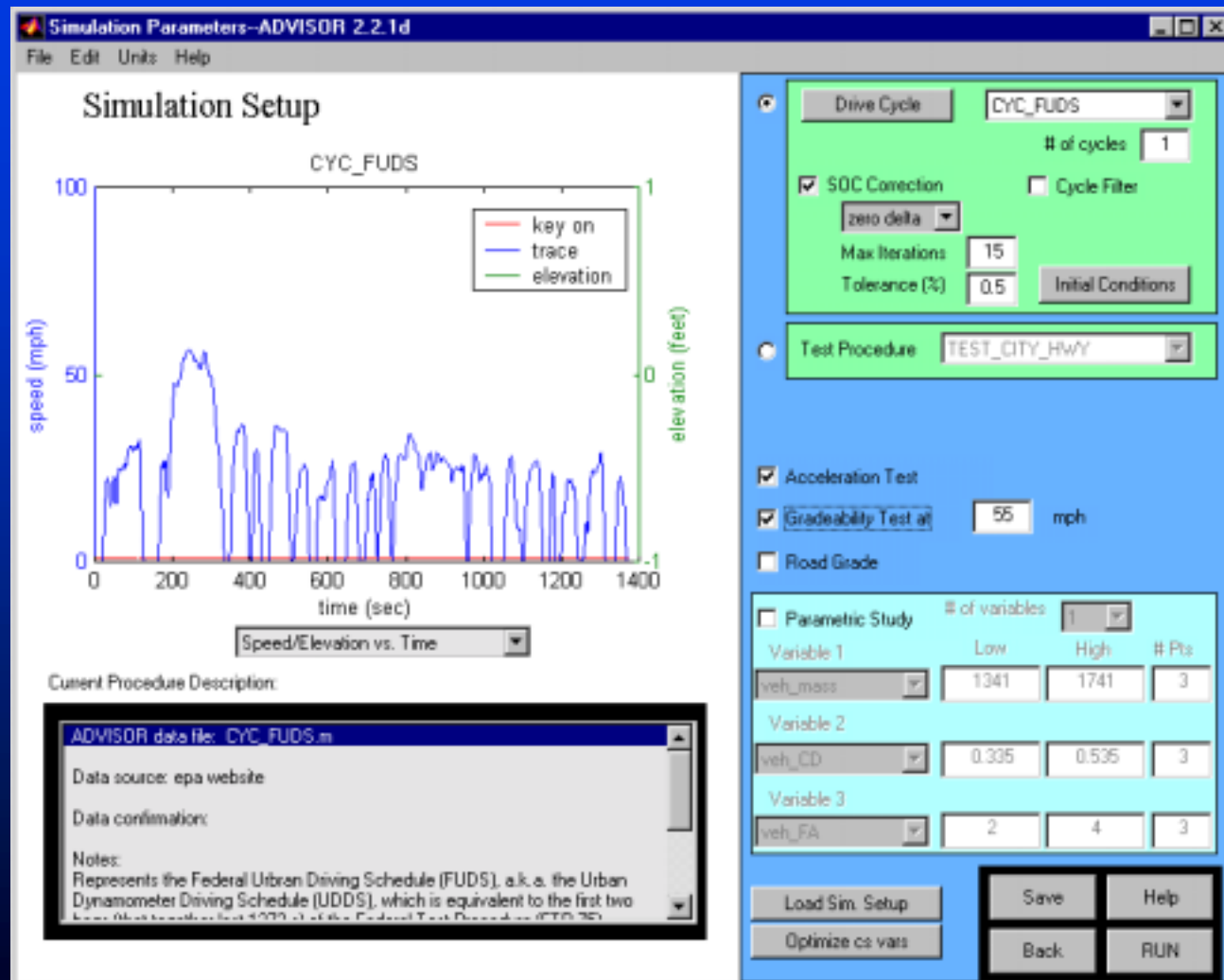
Vehicle Input Screen



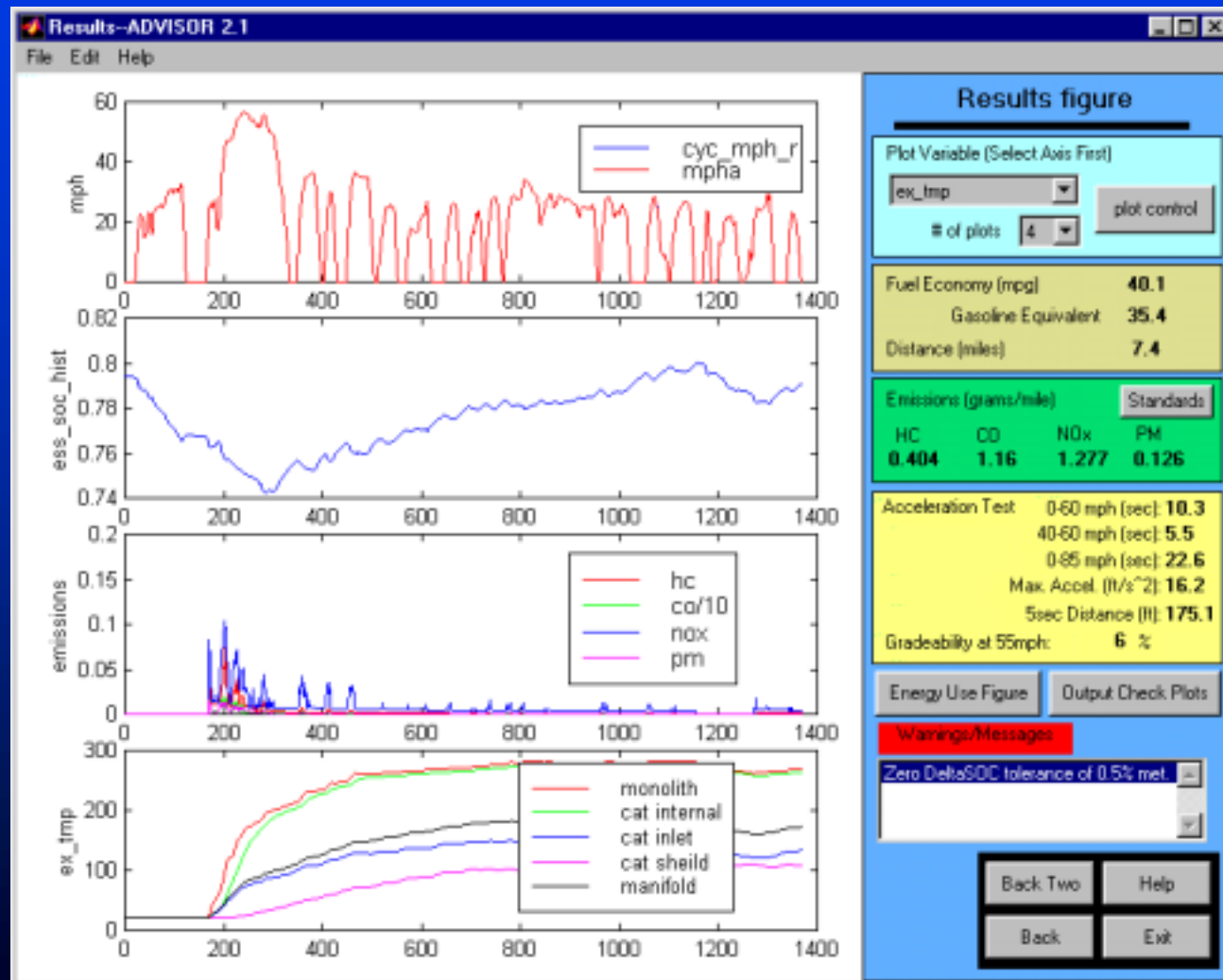
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Simulation Setup Screen

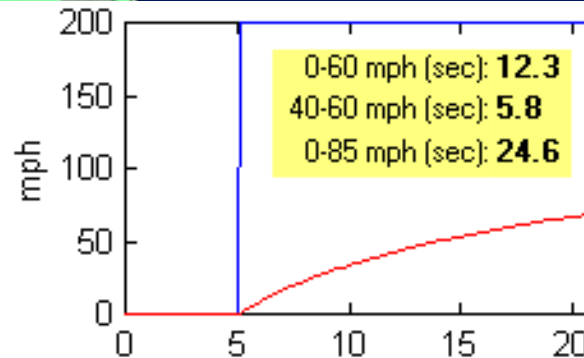
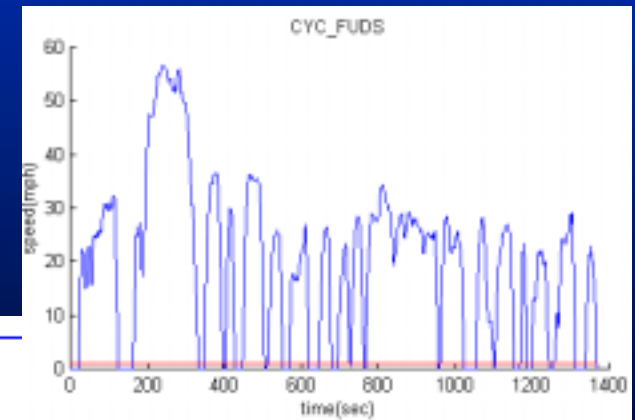
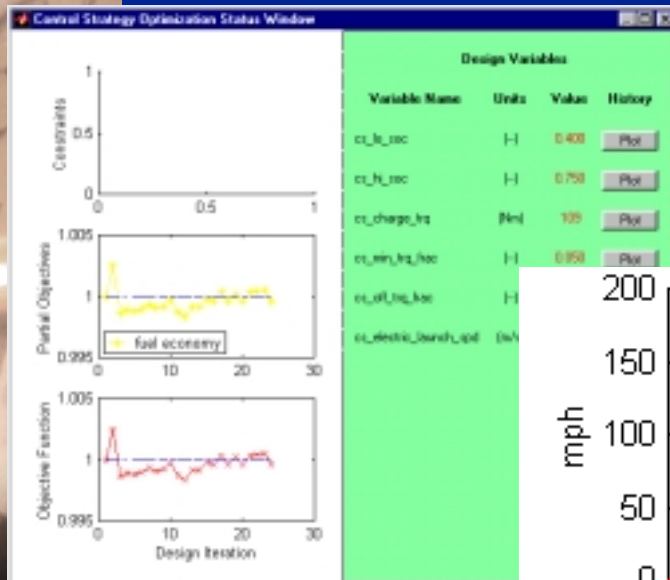
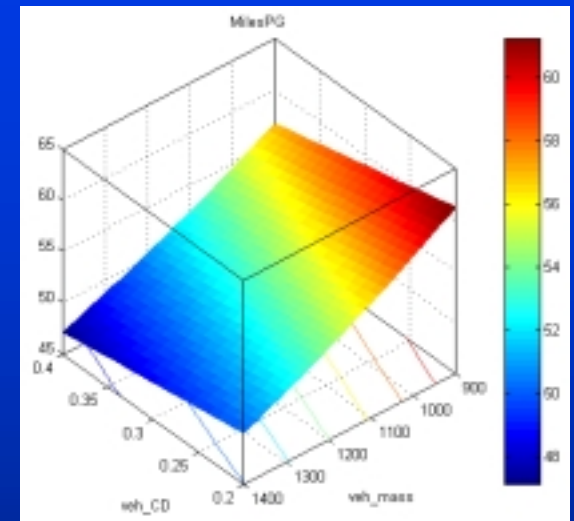


Cycle Results Screen



Types of Simulation Tests Possible

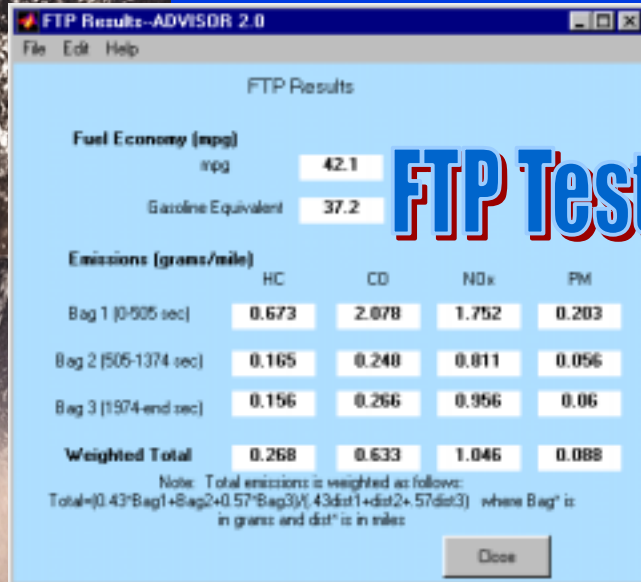
- Parametric sweeps
- Drive cycles
- Acceleration and grade tests
- Control Strategy Optimizations



IES AND SYSTEMS

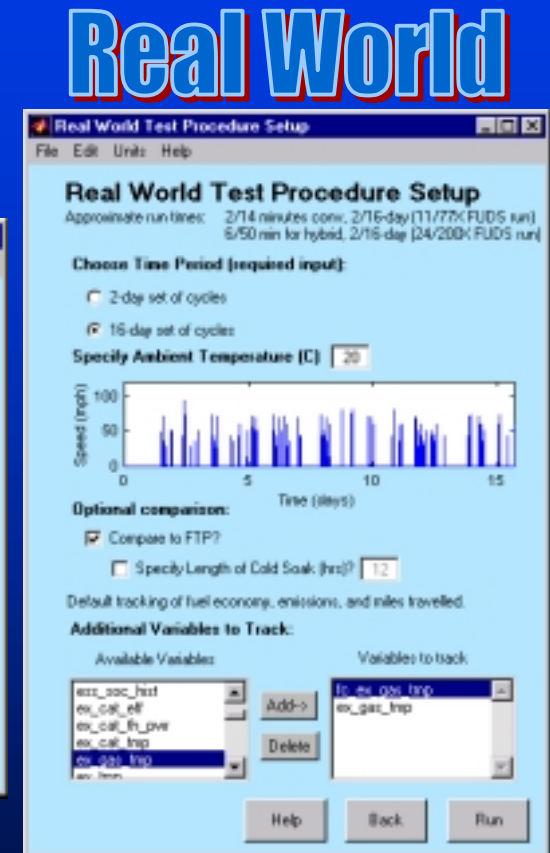
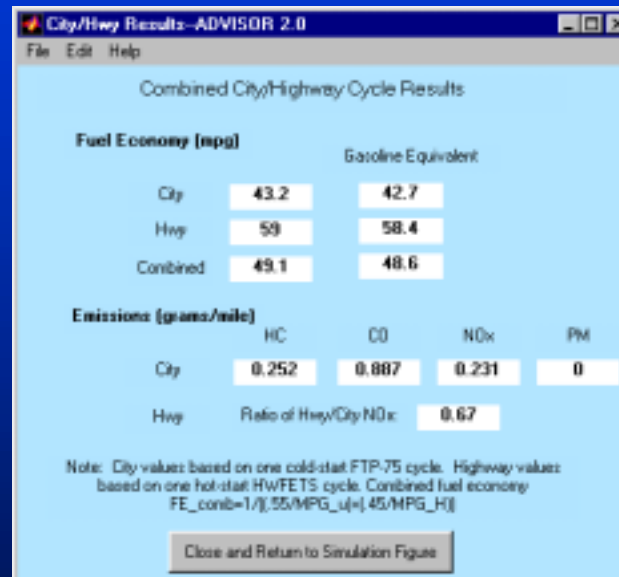


“Test Procedures” Currently Available



FTP Test

Combined City/Highway



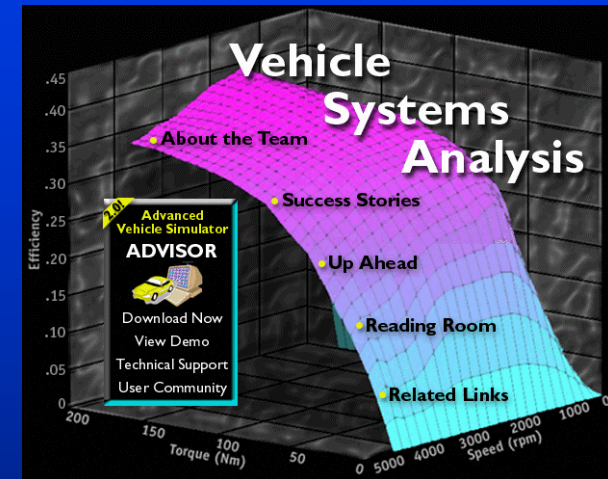
SAE J1711 HEV Test Procedure

CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Software Availability on Web

- NREL's Vehicle Systems Analysis web site launched in September 1998
- ADVISOR 2.2 available for free after filling out simple form (incl. source code)
- 'Forum' has bulletin area for questions to be answered and files to be shared
- Documentation viewable from web site
- Reading room has all papers and presentations from team



Keith Wipke, Matt Cuddy, Sam Sprik, Steve Burch,
Valerie Hovland, Tony Markel.

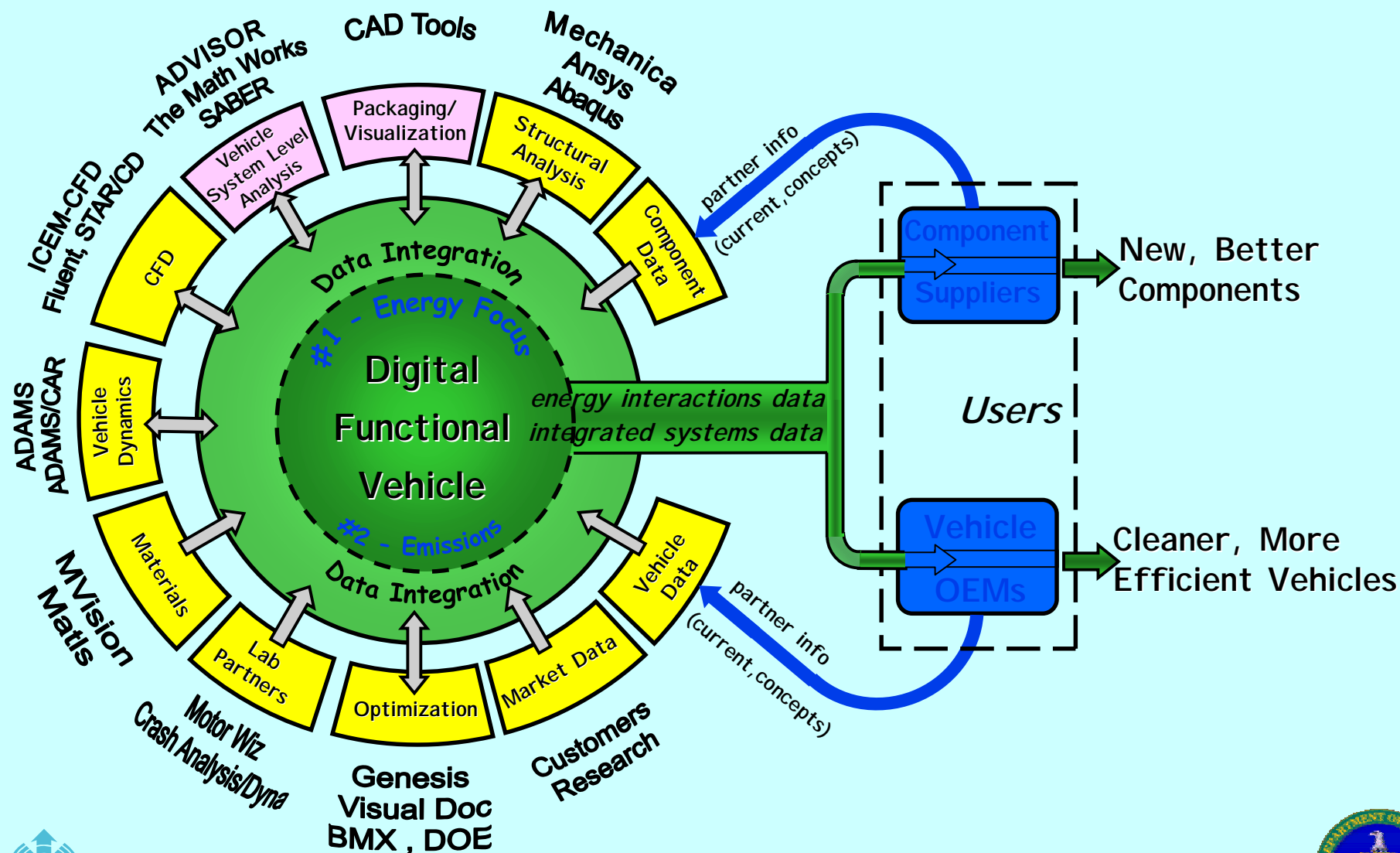
Not pictured: Matt Keyser, Desikan Bharathan



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Example of Linkage with Packaging



Loading ADVISOR Vehicle into Pro/HEV

Pro/HEV 1.1 - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Plug-in Security Shop Stop

Bookmarks Location: <http://192.174.54.60/prohev/prohev.htm> What's Related

NATIONAL RENEWABLE ENERGY LABORATORY

Pro/HEV

NREL
DOE | NREL | ADVISOR

FILE

- ▶ [Load HEV]
- ▶ [Save HEV]
- ▶ [Load Defaults]
- ▶ [Clear]

ANALYSIS

- ▶ [Configure]

EDIT

Design Summary:

Vehicle Name:	<input type="text" value="Default small car"/>		
Energy Storage Name:	<input type="text" value="Default ESS."/>		
Wheel-axle Name:	<input type="text" value="Default suspension."/>		
ADVISOR Data:	<input type="text" value="UNKNOWN"/>		

Vehicle Class:	<input type="text" value="SMALL CAR"/>	Number of passengers:	<input type="text" value="5"/>
Wheelbase:	<input type="text" value="2640.0"/> mm	Number of modules:	<input type="text" value="20"/>
Drivetrain Type:	<input type="text" value="SERIES"/>		
Track (front):	<input type="text" value="1440.0"/> mm		
Track (rear):	<input type="text" value="1440.0"/> mm		

Last updated Monday, November 15, 1999 09:29:14

[Pro/HEV Site Map](#) || [Help](#) || [Search](#) || [Email](#) || [Design Summary](#)

Contact: NREL, 1617 Cole Boulevard, Golden, CO 80401-3393 prohev@nrel.gov

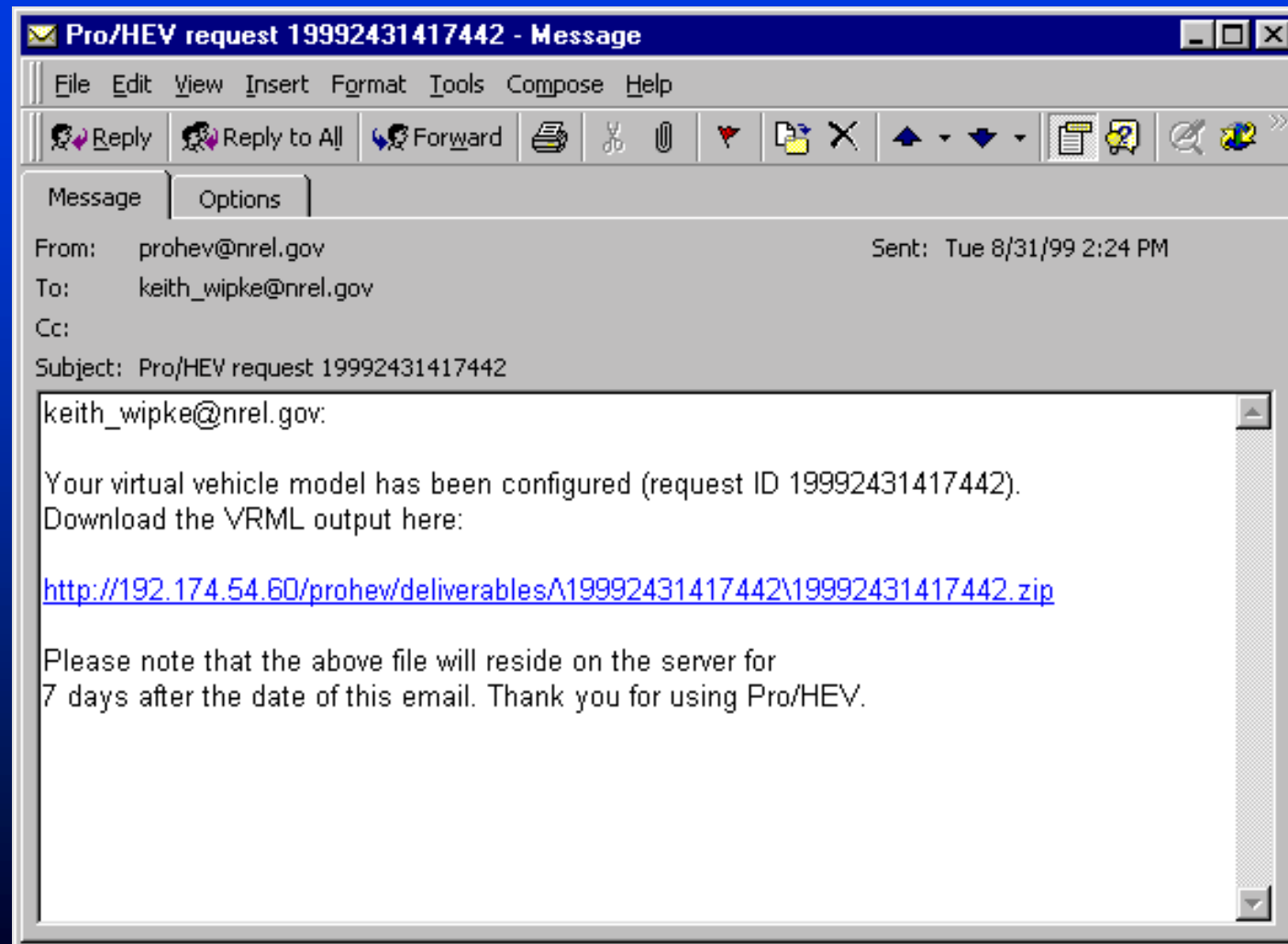
Document Done



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



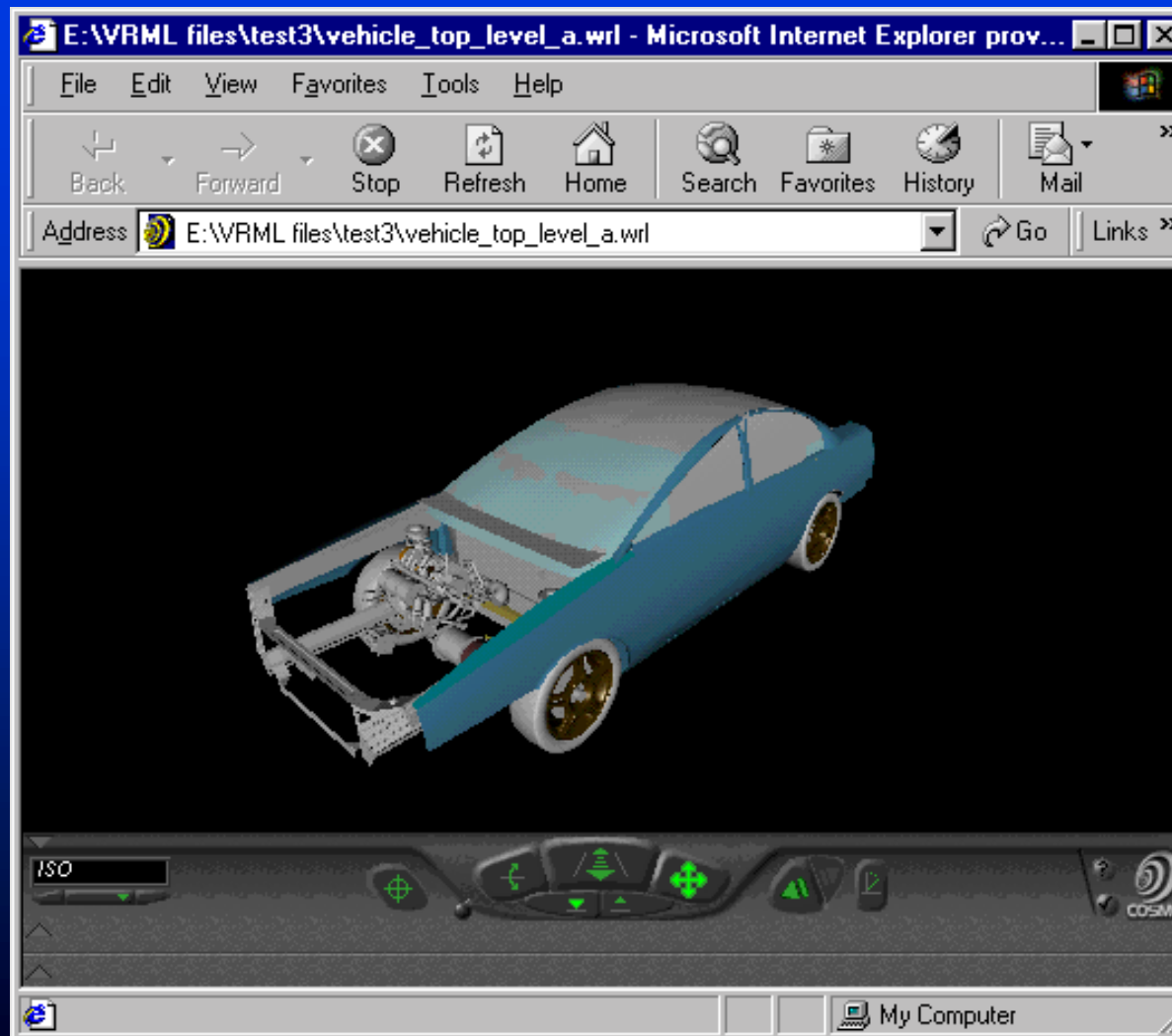
E-mail notification of VRML files



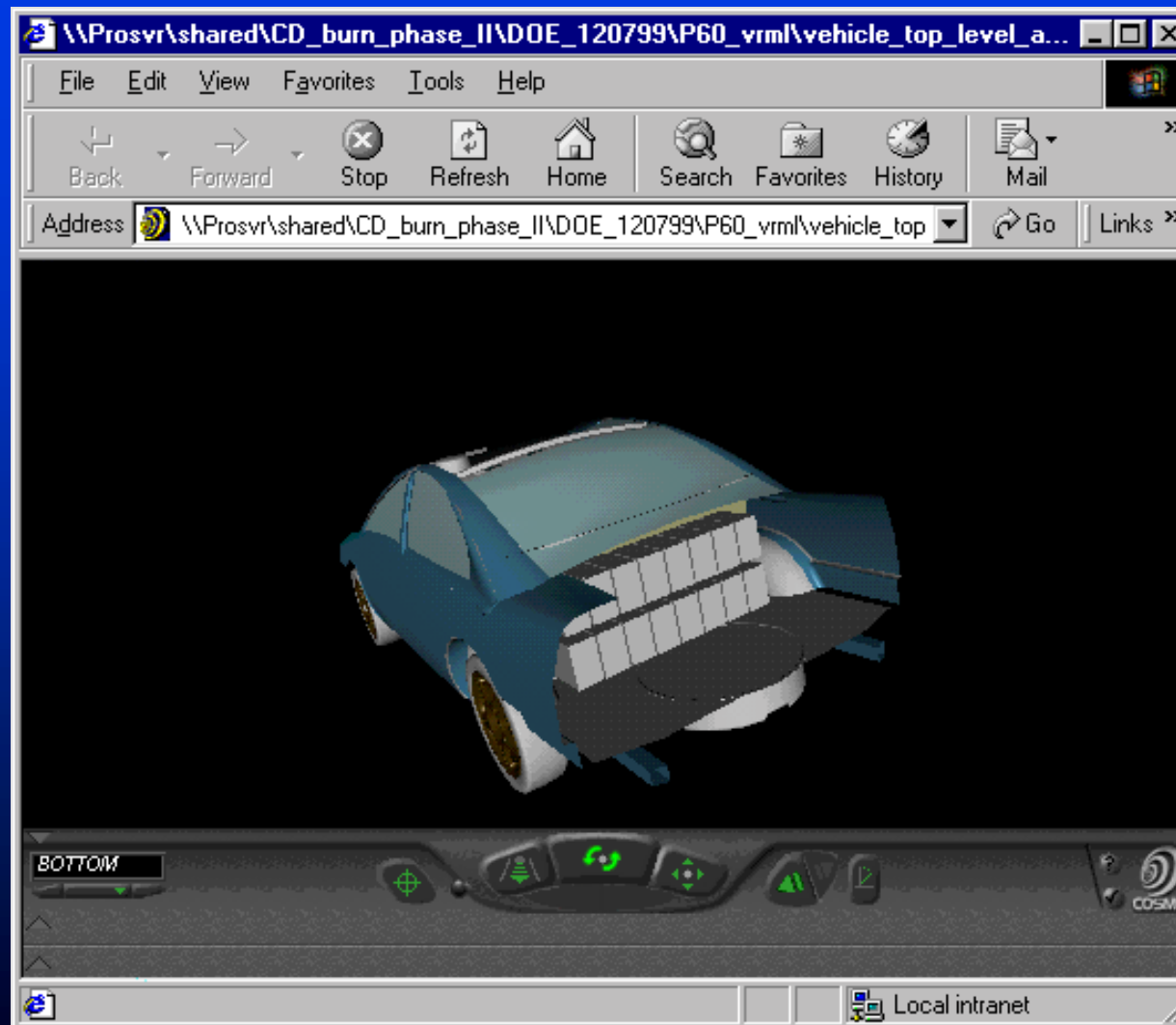
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Visualizing VRML Vehicle in Browser

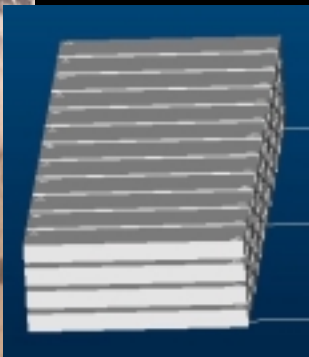


Visualizing VRML Vehicle in Browser



Battery Packaging Comparison from Previous Study (for illustration purposes)

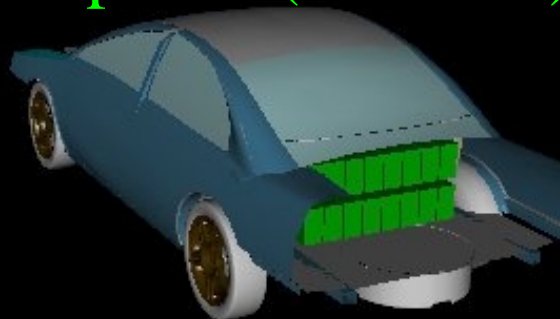
Prius (NiMH)



Battery "A" (Li-ion)



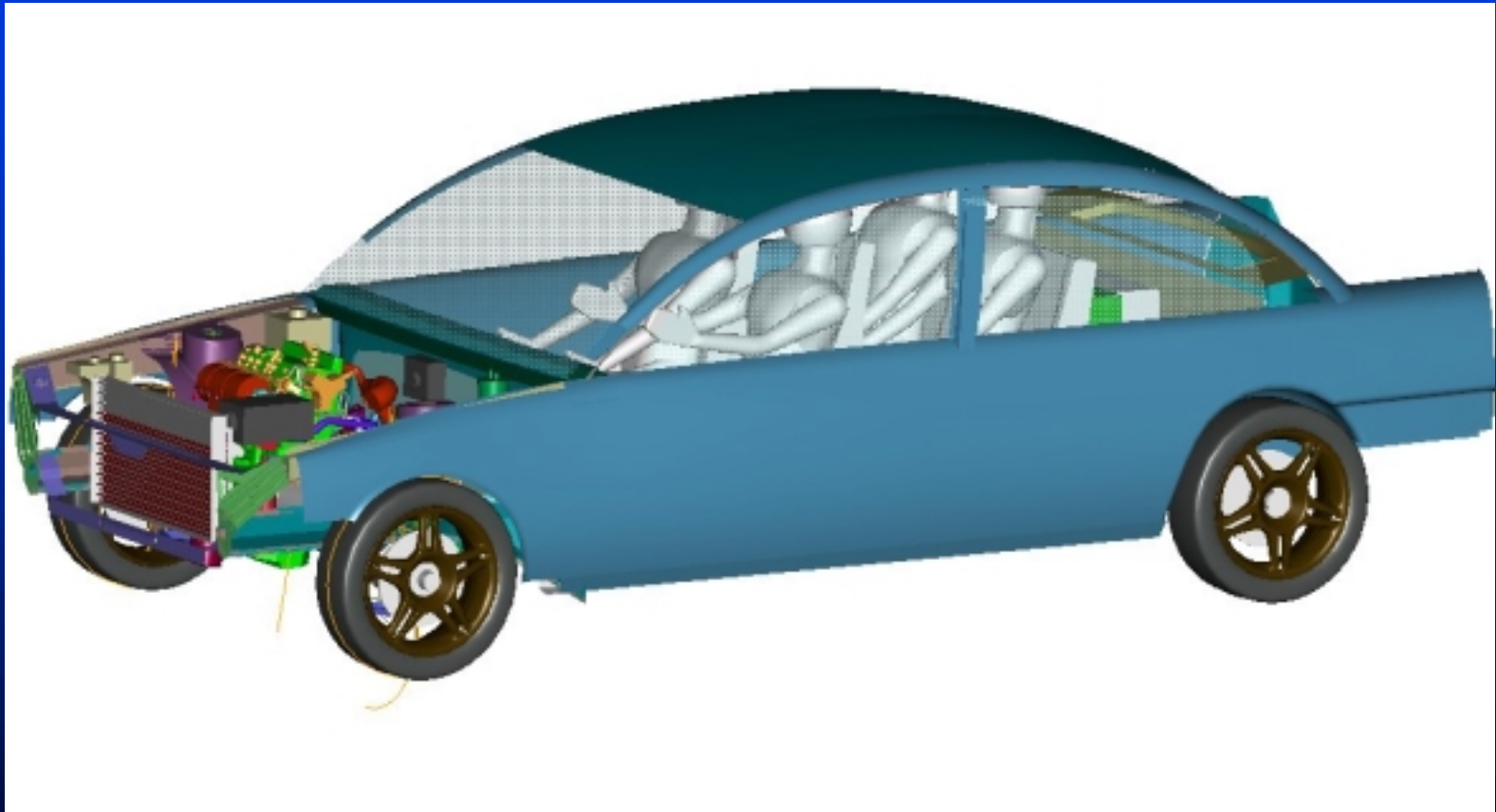
Optima (Pb-Acid)



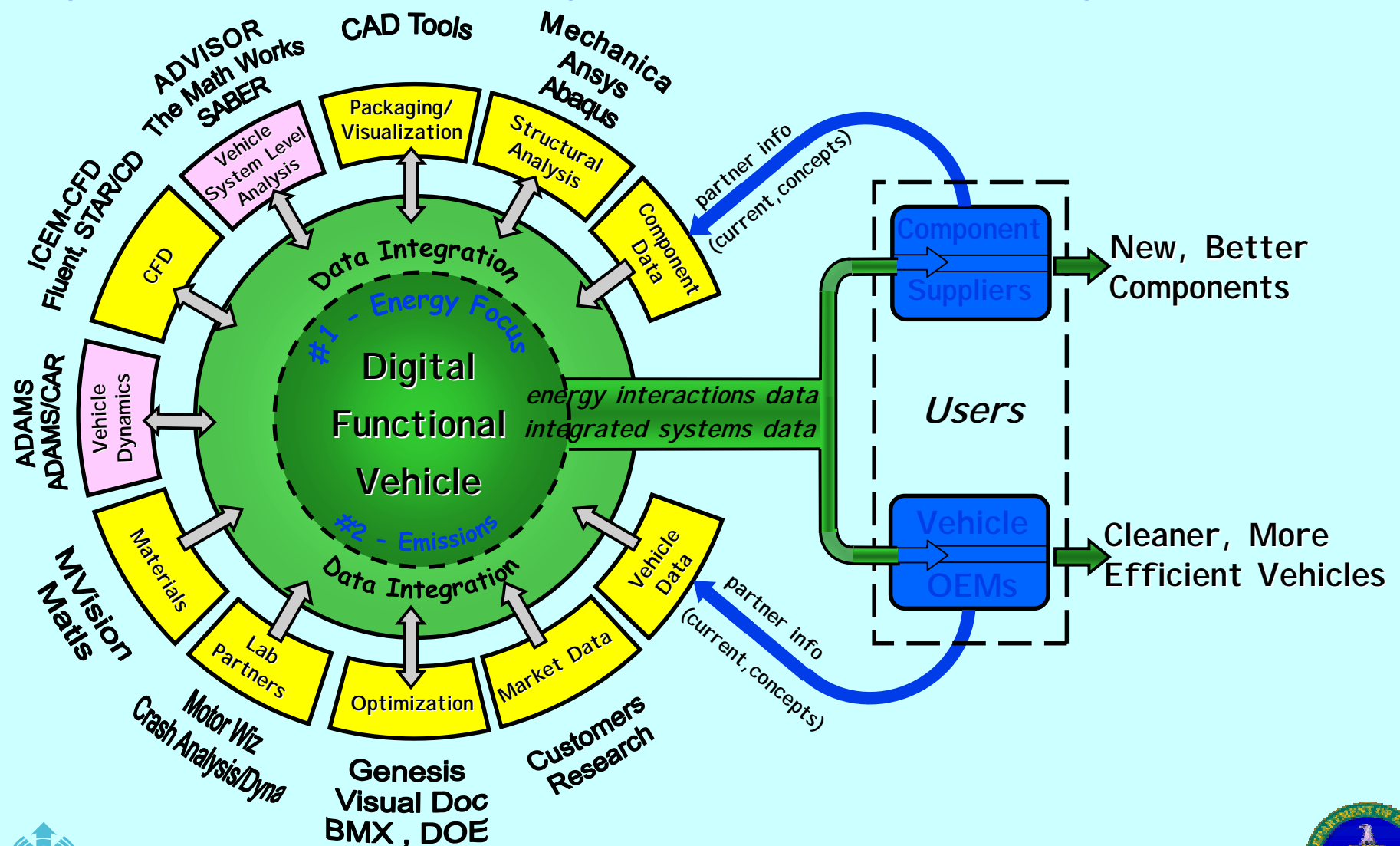
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Full Parametric Vehicle Assembly also Includes Geometry Useful for Many Groups at NREL



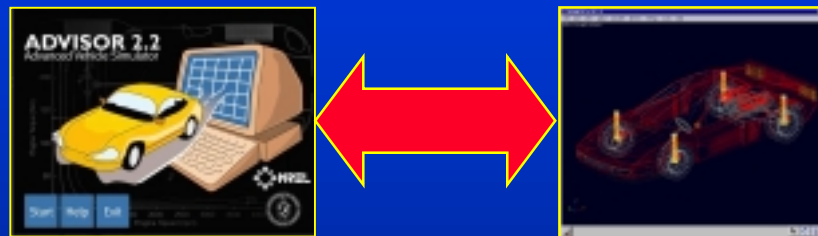
Digital Functional Vehicle Wheel: Linking Systems Level Analysis with Vehicle Dynamics



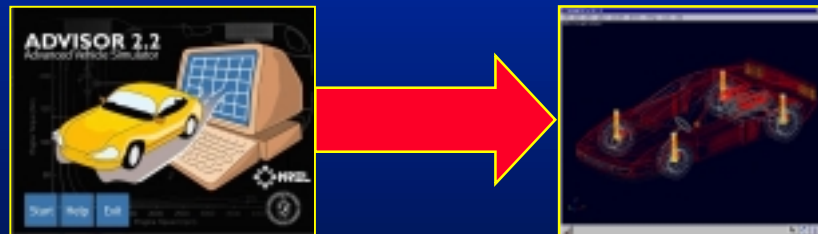
Outline:

Interfacing ADVISOR and ADAMS/Car

- Two interface approaches will be used:
 - ADAMS/ADVISOR Co-simulation



- Export to ADAMS/Car



- Each approach has its own advantages and serves different simulation purposes.

ADAMS/ADVISOR Co-simulation

- ***What?***

- Linking ADAMS/Car full vehicle model with ADVISOR model
- Both ADAMS and Simulink solvers run together
- Information passed back and forth between the two at each time step

- ***How?***

- ADAMS/Car full vehicle model using customized powertrain template
- Modified ADVISOR model to work with ADAMS/Car model



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



ADAMS/ADVISOR Co-simulation

- *Why?*

- Simulate 4WD/AWD powertrains
 - torque split can be actively controlled by ADVISOR
- Vehicle handling/dynamics with new CM from ADVISOR
 - can look at stability issues relating to battery placement
- Calculate energy losses during handling/durability events
 - useful for trying minimizing losses for maximum fuel efficiency
- Integrate accessory loads (like electric power steering) and look at their energy impact vs. performance
- Trade-offs to accurately assess impact of vehicle/component mass reduction and evaluating effect on dynamic performance
- Perform anything you would normally do in ADAMS/Car, but using an advanced powertrain from ADVISOR



ADAMS/ADVISOR Co-simulation

- **Overview**

Preprocessing

Pro/Engineer

Mass, Inertia
& Geometry

Analysis

ADAMS/Car
Full Vehicle Model

Customized
Powertrain Template

Co-simulation

ADVISOR

Postprocessing

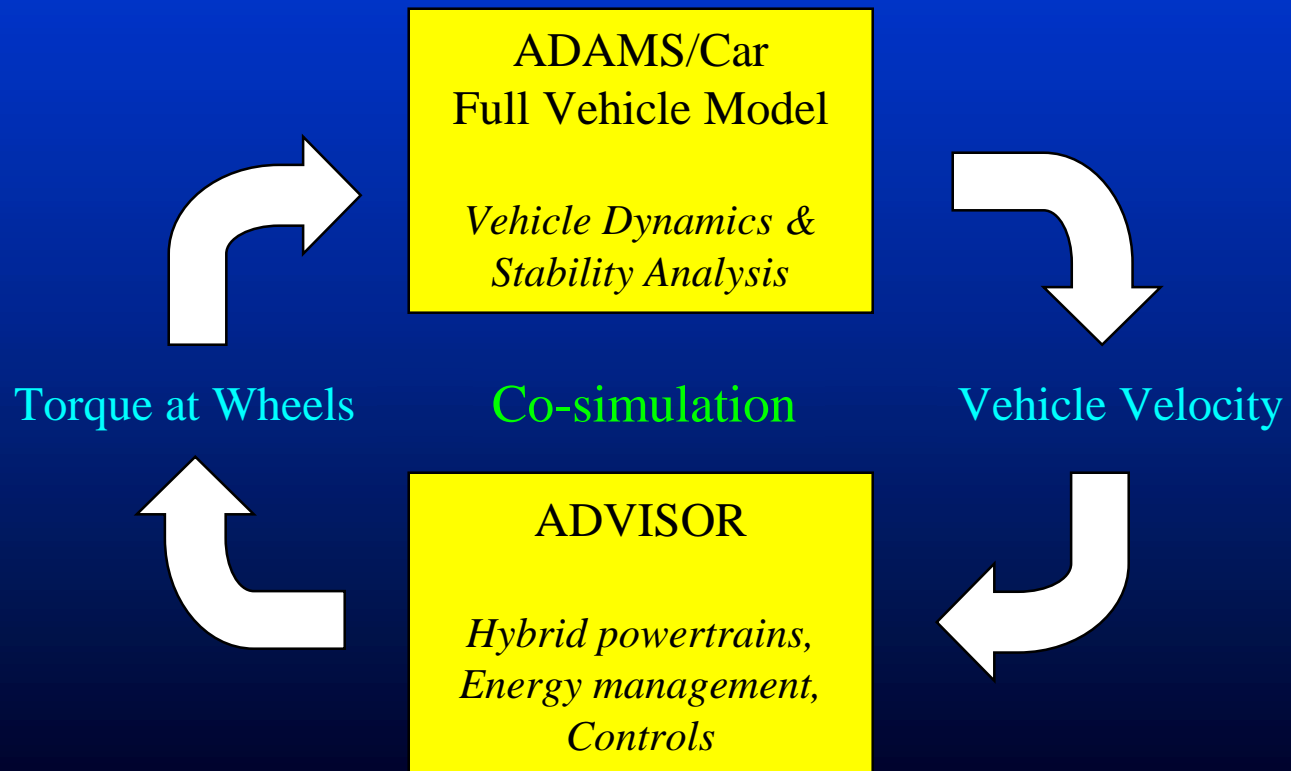
Handling Results,
Animations

Energy losses, Emissions,
Fuel efficiency, etc.

ADAMS/ADVISOR Co-simulation

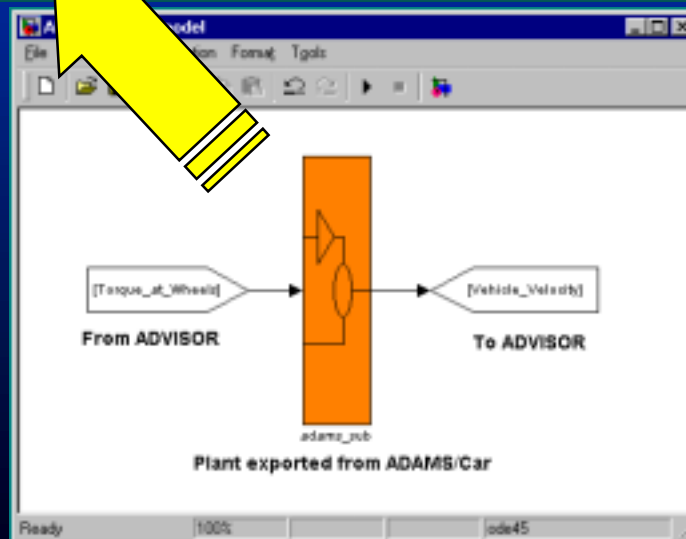
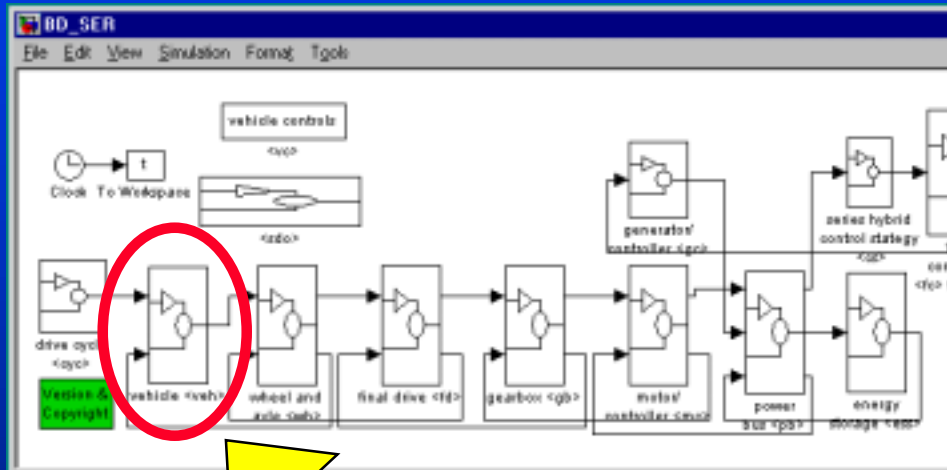
- **Information Flow**

- The major variables exchanged are shown below. Additional information will also be exchanged.



ADAMS/ADVISOR Co-simulation

- Exporting ADAMS/Car Plant to Simulink



Block Parameters: ADAMS Plant

MDI/ADAMS Plant (mask)
Simulate any MDI/ADAMS plant model either in ADAMS/Solver form (.adm file) or in ADAMS/View form (.cmd file)

Parameters

ADAMS install directory
ADAMS_dir

User executable (opt.: if blank - use standard)
ADAMS_exec

Initial Static Simulation Flag
ADAMS_static

ADAMS model file prefix
ADAMS_prefix

ADAMS/View input names
ADAMS_inputs

ADAMS/View output names
ADAMS_outputs

ADAMS/Solver in/output IDs
ADAMS_u_y_ids

Direct feedthrough number
0

Output files prefix (opt.: if blank - no output)
[plant_out]

Output step size
0.005

Simulation mode
discrete

Animation mode
batch

Initialization mode
automatic

Initialization commands
[]

OK Cancel Help Apply



CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Export to ADAMS/Car

- **What?**
 - ADAMS/Car full vehicle model with mass and inertia properties exported from ADVISOR
 - One way information flow to ADAMS/Car
- **How?**
 - Output mass and inertia properties from ADVISOR to ADAMS/Car.
 - Optionally, geometry may be specified in web interface
 - Run standard handling maneuvers in ADAMS/Car



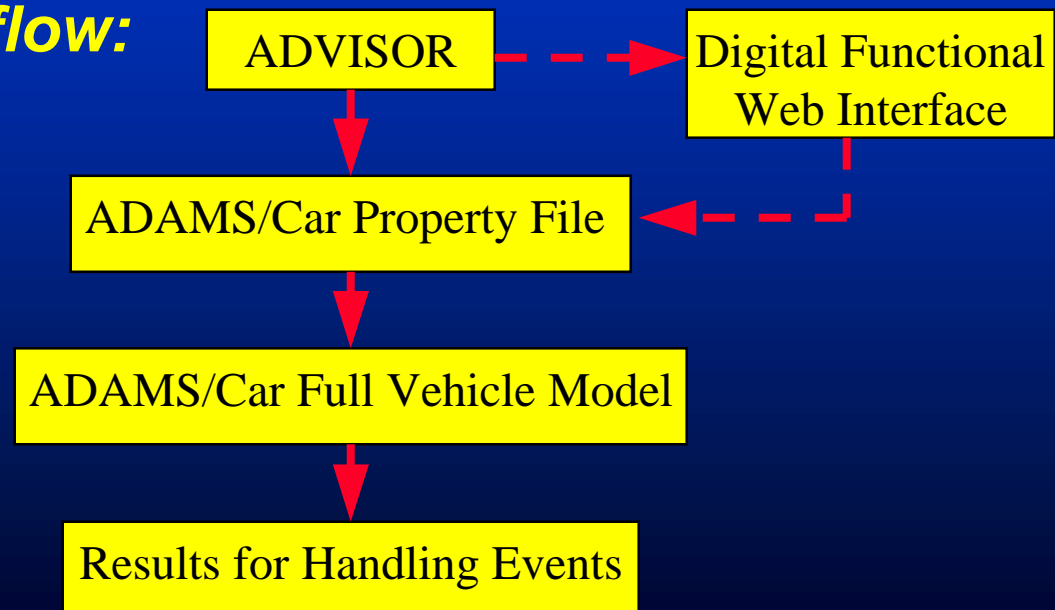
CENTER FOR TRANSPORTATION TECHNOLOGIES AND SYSTEMS



Export to ADAMS/Car

- **Why?**
 - Faster simulations
 - Quick estimate of handling performance of hybrid vehicle
 - Example: allows analysis of battery pack location (often a large mass) and effect on handling

- **Information flow:**



Conclusions

- ADVISOR 2.2 is a user-friendly simulation tool available to the public through the web
 - www.nrel.gov/transportation/analysis
- Widespread usage of the model globally has led to a large database of components and vehicles
- NREL is working with industry to link ADVISOR up to tools they use, such as:
 - Pro/E (visualization, packaging)
 - Visual-Doc (Optimization)
 - SABER (electrical)
 - ADAMS/Car (vehicle dynamics)
- Looking for input from active ADAMS users on how they might benefit from and guide this linkage with our advanced powertrain modeling linkage (ADVISOR)

